Transaction Costs and Institutional Innovation: Sustainability of Tank Aquaculture in Sri Lanka

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Abstract

Freshwater community-based aquaculture was introduce to village irrigation tanks in the dry zones of Sri Lanka in order to off-set the limited supply of animal protein available to residents in inland areas. This paper examines transaction costs associated with the management of community-based aquaculture in Anuradhapura district, the most important inland fish production area in the country. Using data from 41 tanks and 340 households, the study finds that community-based aquaculture involves three types of management forms: tank management by farmer organizations, mangaement by sub-group within farmer organizations and out-sourcing of management to third parties. All three institutional arrangements involve transaction costs associated with information provision, collective decision-making, and protection of fish harvest from poachers. While the costs of information provision and collective decision-making are relatively low under all three institutional arrangements, the cost of protection is significant and is considerably reduced when the entire farmer's association is involved in tank management. In general, while community based fisheries contributes cash flow to farmer organizations and bolsters village food security, the benefits to individual farmers are low. Hence, farmers have little incentive to participate in collective action. Of the three different institutional arrangements, management by farmer sub-groups is the most successful in providing benefits to participants. The study suggests that sustainability of community-based aquaculture depends on successes in experimenting with institutional arrangements that can minimize transaction costs and achieve adequate returns to participants through productivity gains from tanks.

Key words: Community-base aquaculture, transaction costs, farmer organizations, irrigation tanks, fisheries, Sri Lanka

Transaction Costs and Institutional Innovation: Sustainability of Tank Aquaculture in Sri Lanka

Athula Senaratne and Kalpa Karunanayake

1. Introduction

Rural poverty and malnutrition are common in the dry zone of Sri Lanka. The main source of animal proteins for an average Sri Lankan is fish and nearly 90 % of the supply comes from marine sources (Ministry of Fisheries and Aquatic Resources 2004). The supply of fish from marine sources to inland dry zone areas is limited due to various reasons such as limited surplus available after meeting the demand from coastal areas, inadequate cold transport facilities, and the poor keeping quality of products. Therefore, only a limited supply of animal proteins is available to residents in the inland dry zone areas, leading to high incidence of protein deficiency among them.

One possible strategy to address this problem is to increase the production of freshwater fish in inland areas using the existing infrastructure of village irrigation tanks. Village tanks are basically rainwater-harvesting devices established for paddy cultivation under water scarcity conditions. They have helped achieve the food security goals of successive generations over a period of over two millennia and continue to play an important role in irrigated agriculture even today. In addition to irrigation, village tanks fulfill a variety of other rural agrarian needs, which include traditional fisheries, domestic water uses, bathing and washing, and animal husbandry. But village irrigation tanks are common property resources (CPR) and all user rights are defined with respect to an identified community of villagers. Hence, utilization of village tank resources invariably requires collective action.

Even though village irrigation tanks have the natural potential to support a fish population, a vast majority of them are seasonal reservoirs (Thayaparan 1982). As a result, very low productivity levels have been observed due to intermittent disturbance to fish life cycles during annual drying up of tanks (Chakrabarty and Samaranayke 1983). In order to improve fish productivity in village tanks, scientists have proposed recruitment of fish fingerlings artificially and management of these tanks through community involvement (see Appendix I for details).

Community-based Aquaculture (CBA) in village irrigation tanks has a number of features that appeal to policy makers and development workers. The major policy advantages are: (a) involvement of local resources that directly deals with the rural poor; (b) obligatory need for community participation due to common ownership; (c) ability to cater to a larger section of the population due to widespread distribution of the resource-base; (d) the low cost nature of the technologies involved and their successful demonstration; and (e) the potential to address the problems of poverty, malnutrition and unemployment simultaneously. As a result, CBA has gradually captured the attention of stakeholders such as the central government agencies, provincial governments in the tank areas, donors, and NGOs.

CBA in village tanks is introduced through a local institution called 'Farmer Organizations' (FO) which is an institution established primarily for irrigation water management for paddy farming. The objective of this model is to promote aquaculture as a rural enterprise undertaken by community groups, with only the initial catalytic support by the government. As FOs are community-based organizations, aquaculture in village irrigation tanks is essentially a collective action venture.

Collective action requires cooperation among resource users. In the case of CBA, however, the issue of cooperation among resource users is complicated by a number of factors. Village tanks and associated institutional arrangements have evolved historically in the context of subsistence, family-based farming systems, which depended on commonly held rights over a majority of other village resources too (Somasiri 2001; Ulluwishewa 1997). This traditional subsistence farming system is currently being replaced by a commercialized system where associated resource ownership patterns too are transforming themselves to predominantly privately-owned resources. Simultaneously, agricultural technologies used by farmers are also being fast 'modernized'.

Further, CBA is a non-traditional use of the resource. Even though small-scale capture fishing has been in existence since ancient times, aquaculture itself is not a familiar practice in village tanks. Collective action for this non-traditional use therefore has to be rallied through an institutional arrangement that developed for irrigation water management. Due to these reasons, the process of adoption of CBA by groups has been exceedingly slow despite the favourable policy climate and positive technical demonstrations.

Researchers have examined the collective action problem in a variety of contexts that involve common property resources (Meinzen-Dick and Knox 1999; Agarwal and Ostrom 1999). Among the most frequently asked questions are why collective action is successful in certain CPRs while it fails in others, and what conditions would ensure successful cooperation among community groups (Wade 1980; Ostrom 1990). Collective action, however, is not a costless phenomenon and involves transaction costs (TC) for information, negotiations, making agreements, ensuring compliance and monitoring (Abdullah, et. al. 1998; Kuperan, et. al., 1998; Hannah 1995). Hence, some scholars have proposed the concept of transaction cost to explain certain aspects of the evolution of institutions that manage CPRs.

In the present paper, we use the concept of transaction cost to examine collective action in CBA in village irrigation tanks of Sri Lanka. The system of village irrigation tanks has managed to survive over a period of two millennia as CPR through its ability to continuously evolve institutional arrangements to adapt to new realities (Panabokke 2001). Given such a time-tested record of collective action, there is great potential to develop CBA in village irrigation tanks. This study, therefore, attempts to:

a) Assess the importance of costs associated with institutional factors that in turn affect collective action; and,

b) Identify suitable institutional arrangements and management strategies that would help ensure sustainable collective action among resource users.

The next section of the paper provides background information on the evolution of institutional arrangements in village tanks and CBA. It is followed in Section 3 by a description of the study site and sources of data used in the study. The methodology and conceptual framework for the study are discussed in section 4 and results of the empirical investigation are discussed in section 5. Section 6 conclude the paper and discussed various policy implications.

2. Background

The last one and a half centuries have been an era of regular experiments when it comes to institutional arrangements vis-à-vis village irrigation tanks wherein responsibilities were shifted from the state to community and vice-versa very frequently (Panabokke, et. al. 2002; Aheeyar 2001). In the past, a tank-village in the dry zone consisted of the following basic components: (a) the tank; (b) the housing area (or *gangoda*); (c) the command area (i.e., the paddy-field area serviced by the tank); (d) the rain-fed upland crop area (*chena*); and (e) the tank catchment (Somasiri 2001). Of these components, common ownership included not just the tank but the lands in the catchment area and rain-fed upland crop areas while the villagers used goods and services extracted from them in usufruct (Ulluwishewa, 1997). Households usually held private rights to plots in the village paddy field and the homestead area.

These traditional resource ownership patterns are presently under transformation. The Crown Lands Encroachment Act, enacted by the British rulers in the first half of the 19th century, initially catalyzed this process (Abeysinghe 1978; Government of Sri Lanka, 1990). The process was further accelerated by: (a) commercialization of local economies; (b) 'modernization' of agriculture; and (c) increasing population (Aheeyar 2001; Leach 1971; Panabokke, et. al. 2002; Ulluwishewa 1997). Accordingly, most communally held lands allocated for highland crops and tank catchments have been converted to permanent, private lands (Ulluwishewa 1997). These changes in ownership and tenure patterns were closely followed by ensuing changes in institutional arrangements.

The transformation in the tenure pattern coincided with the launching of the village-tank aquaculture programme by the former Inland Fisheries Division of the Ministry of Fisheries in the late seventies (Chakrabarty & Samaranayake 1983; Thayaparan 1982; Chandrasoma 1986). This programme was carried out as a promotional activity of the state with the support of a few individuals selected from the tank sites who were provided with fish fingerlings from government breeding centres. It was the experience gained from this programme that helped establish the technical feasibility of aquaculture in seasonal village tanks. Despite early signs of success, however, the aquaculture programme faced total collapse in 1990 when the government decided to withdraw support for the inland fisheries and aquaculture sector. This revealed the vulnerability of the initial model where no significant attempt was made to install a suitable institutional arrangement at the local level. The programme was resumed again in 1994 when the government reinstated support to the inland fisheries and aquaculture sector. It was introduced as a community-based venture organized under the patronage of FOs with the government providing only the initial catalytic support.

The outcome of the community-based aquaculture programme since the resumption of state support however has been mixed. While a handful of communities have succeeded in completing a few cycles of production on their own initiative, the programme has faced problems in many tanks after external support was lifted. These failures are usually attributed to reasons such as inadequate number of extension staff and poor dedication of extension workers; scarcity of fish fingerlings; poor coordination among relevant stakeholders, etc. Although these reasons no doubt explain the slow progress of the state programmes carried out to provide initial catalytic support, they have limited explanatory potential from an overall policy perspective. It is highly unlikely that initial catalytic support from the state would be provided to all feasible village irrigation tanks even in the long run. Finally, the success of interventions like this depends largely on the voluntary adoption of collective action by community groups on a large-scale who would ensure its feasibility by setting an example of success to neighbouring locations.

In the following section we describe the study area and method of data collection adopted for the analysis in this paper.

3. Study Area and Data Collection

This study was conducted in 2003-2004 in the Anuradhapura district, which is located in the heart of the dry zone in Sri Lanka. It is also the district with the highest inland fish production in the country and houses 2334 inland water bodies covering a total inland water area of 51,500 ha. It ranks first in the country in terms of consumption of freshwater fish with 2,482 g/month per household as CBA has been practised in the highest number of village tanks here. Hence, Anuradhapura District naturally becomes first choice for the study area.

This study is based on primary data collected both at the community (tank)-level as well as the household level. Community-level data was collected using a checklist whereas an interview schedule was used to elicit household information.

Information was collected from a total of 41 tanks covering a majority of locations where CBA had been practiced during the recent past. The cross-section of selected sites included tanks where CBA had been practised continuously for a few cycles after initial catalytic support was lifted as well as tanks where programmes were abandoned after one or two cycles. Information about each tank and the community it supported was collected from a number of sources, including official records, village officers, agriculture and irrigation officers, members of FOs, and village elders. The tank level data was collected on the following major aspects: (a) physical information on the seasonal tank; (b) details on agricultural activities and irrigation; (c) details on fish production in tanks (i.e., details of past culture cycles, economic cost/return details on last culture cycle, organizational arrangements, group characteristics, funding of fish culture programmes, organizational activities/meetings, time-allocation, supporting organizations/extension services, marketing, etc.)

Household-level data was collected from 340 randomly selected households in the 41 tank sites covered by the survey. The household sample consisted of 208 households that had participated in CBA at least once while the remaining 132 households were non-participants. The sample households represented a total population of 1632 of which 50.5 % were females. The average family size was 4.8. The household survey gathered information on the following aspects: (a) living conditions/facilities and ownership of assets; (b) location and infrastructure facilities in the village; (c) income and sources; (d) household expenditure and credit; (e) details on agriculture activities; (f) the nature of involvement in fish culture activities (i.e., contribution, labor use, organizational involvements, sharing of benefits, etc.).

Table 1 provides a social profile of the households covered in the survey. As evident, the sample represented a somewhat homogeneous social group consisting mainly of households coming from the Sinhala-Buddhist ethno-religious background. On the whole, households were related to each other through kinship. In the case of participants, the overall income recorded a significant contribution (35 per cent) from seasonal sources whereas non-participant households had a higher share of income from regular sources (74 per cent). However, no significant difference was observed in the total income of the two groups.

Table 1: A socio-economic profile of households surveyed

Household Parameter	No. Households	%
Head of the household		
Male	330	97.0
Religion		
Buddhists	309	91.0
Hindu	1	0.0
Islam	28	8.0
Christian	2	0.0
Education (Head of HH)		
No formal education	6	2.0
Grade 1-5	85	25.0
Grade 6-11	150	44.0
O/L passed	71	21.0
A/L passed	24	7.0
University	4	1.0
Major occupation (Head of HH)		
Farming	266	78.0
Government service	26	8.0
Trader	14	4.0
Self-employed	13	4.0
Private sector	11	3.0
Labourer	07	2.0
Fish farmer	03	1.0

Any productive venture, irrespective of type of ownership, involves activities pertaining to input-output transformation and exchange of (property) rights (Eggertson 1990). Costs involved with input-output transformation are the usual ‘production costs’. Exchange of property rights gives rise to ‘transaction costs’ for collecting information, making negotiations, reaching agreements, and enforcement and monitoring of agreements. The concept of transaction cost has been developed as a tool for comparative analysis of institutions by the ‘Neo-institutional Economics’ (NE) and ‘New Institutional Economics’ (NIE) schools (Eggertson 1990; Williamson 1973 and 1998; North 1978 and 1989). Different institutional arrangements are considered as outcomes of the interplay between the behavioural attributes of agents, nature of transactions involved, and associated institutional environments (Birner and Wittmer 2000). The framework is guided by the basic premise known as ‘Discriminating-alignment Hypothesis’, which asserts that transactions that differ in their cost and competence tend to align with ‘governance structures’ (that differ in their cost and competence), that minimize transaction costs (Williamson 1998).

In a common property regime where no one owns exclusive private rights over the resource, exchange of property rights usually requires the creation of institutional arrangements (governance structures) that provide a mechanism for the organization of collective action among stakeholders (co-owners). A given institutional arrangement is usually associated with a corresponding structure of transaction costs. Kuperan, et. al., (1998) attempted to estimate the major types of ex-ante and ex-post transaction costs involved in the context of fisheries co-management. Ex-ante costs are information and collective decision-making costs whereas ex-post transaction costs include enforcement and monitoring costs. They have pointed out that different management regimes (i.e., co-management versus the regulatory approach) tend to enlist different types of transaction costs while the burden of those costs to government and community partners may vary accordingly.

When an existing institutional arrangement is transformed to a new one, changes usually take place in the transaction cost structure as well. Hannah (1995) suggested that the introduction of co-management in place of regulatory approaches tends to shift the high ex-ante transaction cost from the state to the communities. Further, co-management has the potential to increase the ex-ante transaction costs while achieving gains from ex-post transactions (Abdullah, et. al. 1998; Kuperan, et. al. 1998).

The burden of transaction cost could vary among individual households in a given community group too in addition to that between the government and community groups. Adhikari and Lovett (2005) have shown that the transaction cost for community forest management in Nepal is higher for wealthier households compared to poorer households on average though the burden for poorer households as a percentage of resource appropriation costs is higher than that for richer households. Further, the transaction cost varies among different community groups (villages) too.

Based on a study conducted in two co-managed wildlife dispersal areas in Kenya, Mburu, et. al., (2003) show that the magnitude of transaction costs incurred by (individual) land owners is influenced by a number of factors. Among them are: (a) attributes of transactions; (b) bio-physical and ecological characteristics of resource systems; (c) human, social, and financial capital of land owners; (d) losses from human-wild life conflicts; (e) tenure security; and (f) benefits from conservation. They further suggest that the influence of these factors is not the same in different locations and that transaction costs are determined by a combination of factors specific to a local site.

3.1 Transaction Costs for CBA

CBA has the usual production costs and transaction costs. Assuming that there are no significant costs or benefits generated due to the interaction of activities, a simplified model of the overall economic benefit structure in a village irrigation tank can be given as follows.

$$Bt = Bi + Bf + Bo \quad (1)$$

Bt = Total Economic Benefits of the Seasonal Tank
Bi = Net Benefits from Irrigation
Bf = Net Benefits from Rural Aquaculture
Bo= Net Benefits from Other Uses

Given that benefits from aquaculture are conditional upon collective action, the decision rule to adopt CBA in a given seasonal tank can be stated by:

$$Bf > TC \quad (2)$$

TC = Transaction cost of organizing collective action

Table 2 summarizes the major types of transactions associated with organizing collective action for CBA. Each of the mentioned activities involves a certain level of transaction cost, which may or may not be accounted in terms of monetary value.

Table 2: Transactions in CBA in village irrigation tanks

Type	Transactions
Searching and information	Accessing scientific methods and species for culture
Collective decision making	Organizing meetings, reaching agreements, coordinating with authorities
Enforcement and monitoring compliance	Organization of tank preparation actions, stocking, etc.
Prevention of free rider activity	Protection from poaching
Distribution of benefits	Organizing harvesting Monitoring the distribution of benefits

In any collective action context, decision-making takes place at least on two levels, namely, collective (community-level) decisions on adopting the action and individual (household level) decisions on whether to participate in it. The transaction cost structure associated with a given institutional arrangement has a variable impact over the decisions of individual agents and collective groups. The abandonment of collectively adopted decisions on the grounds of poor participation by individual members is commonly observed in rural development.

As discussed, collective action for CBA in village tanks is usually the responsibility of FOs. Accordingly, certain elements of transaction costs are incurred by FOs. In addition to these, there are elements of transaction cost that are borne individually by members mainly as labour-time contribution. While a part of this contribution accounts for usual 'production costs', the share of labour used for collecting information, negotiation, reaching agreements, and monitoring activities represent transaction costs. Since all contributions from households have opportunity cost implications, the share borne by a household becomes a deciding factor that influences individual participation in CBA.

Table 3 presents the major types of transaction cost involved and methods adopted to measure them in our study. Most transaction costs are incurred as opportunity cost of time and only a limited amount of direct cash payments are involved. In rural economies, time costs incurred by households are not always backed by observable 'monetary values' based on market-based prices. Instead, such decisions rely on 'shadow prices', which reflect the opportunity cost of time (Sadoulet and De Janvry 1995). In estimating transaction costs, general wage rates available in the area for agricultural labour was used as a proxy for the opportunity cost of time. Monitoring activities such as watching for poachers was an activity usually undertaken during the night. Application of general wage rates in this case was hence not appropriate. However, this activity was carried out by hired watchers in 7 tanks and the average wage rate paid for these watchers was applied to estimate the cost of watching by unpaid community members in other tanks too. In all other cases, cost was measured in terms of the average wage in the specific community multiplied by the total time spent on the transactions plus any cash payments.

Table 3: Methods of estimating transaction costs

Transaction	Nature of Transactions	Nature of Cost	Approach
Organization of collective action	Meetings/ dealing with agents	Time for meetings/ action	Value of time (WR × time)
Ensuring the implementation of decisions	Meetings/ dealing with agents	Time for meetings/ action	Value of time (WR × time)
Avoiding free rider activities	Watching/ dealing with officers	Cash payments/ time cost for watching	Wage cost / Value of time (WR × time)
Organizing the sharing of benefits	Meetings	Time for meetings	Value of time (WR × time)

WR = average wage

The transaction cost in CBA was computed for the different institutional arrangements adopted for CBA. This analysis and their implications are discussed in the following sections.

4. Analysis of Findings

In the study area there are three types of contractual arrangements: (a) organizing of culture operations by the FO itself (10 tanks; 26%); (b) forming of a separate Fisheries Sub-Committee (FSC) under the FO (27 tanks, 67%); and (c) contracting of rights to culture fish in tanks to another party by the FO (3 tanks; 7%). In one tank, the government had stocked fingerlings without the support of any local institution. In the first two arrangements, a sub-group of FOs had taken on the operational responsibility of the aquaculture programmes while in the third non-members of FO were also involved.

Fisheries Sub-Committees: Establishing a FSC is the dominant contractual arrangement observed in two thirds of the sample. The average number of members in a FSC is 19 (range 6-54). The FSC, always a sub-group of the FO, has been contracted by the FO to carry out aquaculture in return for a share of benefits, usually in cash. The remaining income is shared between the members of the FSC, principally on equal terms but with minor adjustments to reflect contributions by different members. The major feature of this arrangement is that FO members who are not in the FSC do not have any ownership claim for fish harvested after the stocking of tanks. Hence the members of FSC usually carry out their activities more independently while meetings and other organizational arrangements record participation by limited numbers.

Farmer Organization: The basic difference between this arrangement and that of the separate FSC is that under the FO the entire membership has an equivalent claim for the final harvest, the income earned from which is usually credited to the FO's fund. In addition, a portion of harvest is also distributed among the members, usually a small quantity of fish for each household. As far as collective action is concerned, other than meetings to decide on arrangements at which there is participation by a majority of the members, a sub-group of members usually organize and carry out aquaculture operations on behalf of the entire membership. The average size of the fish culture group was 31 (range 3-60), which is significantly larger than that of the FSC. While members who make a greater contribution are paid by the FO, a significant amount of labour comes as unpaid minor contributions from other members. This is an advantage from the point of view of the organization.

Other contractual parties: This arrangement was found only in tanks where the FO is non-functional or quite weak. In the sample, this arrangement was found only in 3 tanks. This is similar to a private rental arrangement as the contracted parties did not have any ownership claim to the resource base (i.e., village tanks) unlike in the other two cases. The smallest-size groups were observed under this arrangement averaging 8 (range 5-13).

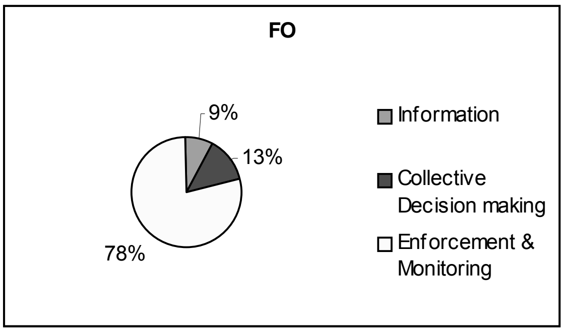
Figure 1 and Table 4 provide details on the three types of transaction cost that have been reported. The costs given in the Table are aggregates of individually incurred costs computed for a given tank. The cost for searching and gathering of information is relatively low due to the specific circumstances found in village tanks. Firstly, members of fish culture groups already possess substantial knowledge, both on resource conditions and contracting parties as they have already obliged on activities based on the same resource with the same group. Secondly, groups are usually small. As per acquiring technical know-how, however, participants have to incur some cost as they have to participate in awareness- and training-programmes conducted by Government Extension Officers on aquaculture operations. It should be noted that this does not include the expenses incurred by the government in order to conduct training- and awareness-programmes.

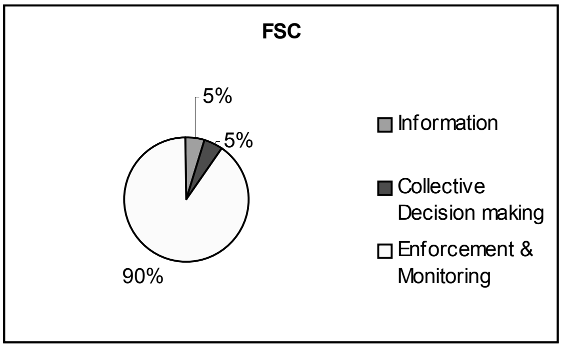
However, groups have to incur transaction costs for making collective decisions, enforcing and monitoring them. The most important fact is that these costs are borne individually by members of the active group, except in 8 tanks where hired watchers were recruited using organizational funds. Many communities hold meetings to decide on organizational matters of CBA on a few occasions (2.5 times on average in the range of 0-4). Usually, costs were appropriated in terms of time and they were valued using a uniform wage rate, which does not reflect the real opportunity cost with respect to a given household. In all three institutional arrangements, work is distributed among members of the active group in a uniform manner (76% in FSC; 70% in FO and 100% in others) while in the case of two tanks there were penalties for neglect of work.

Compared with information and collective decision-making costs, enforcement and monitoring costs were substantial. Enforcement and monitoring costs basically imply the cost of watching to prevent poaching measured in terms of the imputed value of labour and/or actual payments made for the task. Poaching used to be the most important problem faced by CBA in many village tanks. While poaching is an act of theft when engaged in by outsiders, on most occasions the poachers came from the same community. Hence, it can be construed as a form of free riding as well. On a few occasions, litigation was pursued by involving the police for redress.

Table 4 also indicates the transaction cost under the three different institutional arrangements. As evident, the lowest average aggregate TC is reported in FO-managed village tanks while the tanks managed by other parties contracted by the FOs recorded the highest TC. The average aggregate TC of FSC-managed tanks lie in between these two. This result is clearly indicative of the influence exerted by the three institutional arrangements on the behaviour of the village community. In the tanks where the FO itself organized aquaculture, the TC incurred for training and collective decision-making is relatively high as more participants were involved. Yet, given the fact that a wider section of the village community claims ownership of the fish cultured in tanks, the TC for protection of the harvest is relatively low. When the FO contracted the rights of fish culture to a sub-group (FSC) or to another party from outside, they have to incur more TC to protect the harvest from theft, or free riders, in successively high amounts. This reflects the villagers' perception of ownership of fish cultured in tanks under the three different institutional arrangements.

Figure 1: Share of transaction cost under different institutional arrangements





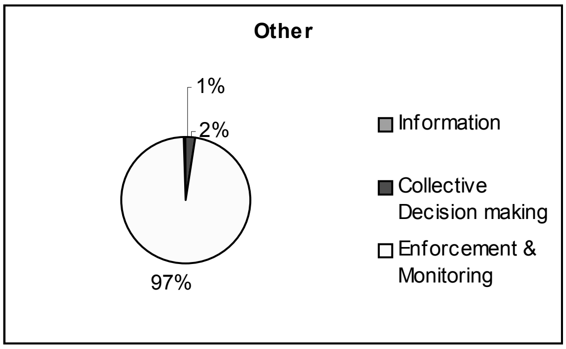


Table 4: Transaction cost under different institutional arrangements (tank per cycle of production)

Institutional arrangement	Information cost (Rs)			Collective decision-making cost (Rs)			Enforcement and monitoring cost (Rs)			Total transaction cost (Rs)		
	Average	Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min
Farmer Organization	2,179 (8.6%)	9,010	-	3,187 (12.7%)	8,116	-	19,722 (78.6%)	77,520	1,520	25,088	79,620	3,420
Fisheries Sub-committee	1,854 (5.2%)	9,450	-	1,793 (5.0%)	9,075	-	32,069 (89.8%)	136,800	2,280	35,717	138,750	2,280
Other	375 (0.06%)	1,500	-	1,150 (2.6%)	1,600	-	53,010 (97.2%)	168,720	-	54,535	168,720	500
Overall	1,744	9,450	-	1,998	9,075	-	30,319	168,720	-	34,012	168,720	-

Production and efficiency of CBA

Production and returns from the tanks were highly variable. As Table 5 shows, on average, the value of fish relative to agriculture in the selected villages is only about 5%. This relative value is 4.1 % in FO-managed tanks whereas in the case of FSC managed tanks it is 5.6 %. Given the magnitude of benefits involved, it is apparent that aquaculture is not capable of providing a major livelihood for all members of a given community. As a result, in all three institutional arrangements, the organizational responsibilities of CBA have been passed on to a smaller sub-group of stakeholders of the tank.

Table 5: Relative Income contribution in CBA

Value parameter	Total annual value of irrigated paddy (Rs)	Total annual value of cultured fish (Rs)	Avg. share of value of fish (%)
Average	4,883,842	74,654	4.8
Max	125,537,665	540,000	33
Min	96,925	-	-

A net-benefit analysis was conducted in order to assess the economic viability of the system. It shows that nearly 60% of tanks managed by the FOs as well as the FSCs indicate positive net margins. Tanks managed by the FSCs have recorded the best performance in terms of average production, fish productivity per unit area, and total value of production and net margin, compared with the other two arrangements (Table 6). Even though higher average revenues were indicated for a few tanks managed by other contracted groups, they experienced higher average costs, too, particularly for the harvesting of fish using hired labour which resulted in a net loss overall. Tanks managed by the FOs indicated a moderate situation as far as economic returns are concerned. The results of the net-benefit analysis indicate that village tank aquaculture has the potential to qualify as an economically efficient system in a significant number of tanks.

However, the net-benefit analysis was conducted using conventional criteria and the TC was not taken into account in the analysis. Therefore, an attempt was made to assess the efficiency of the system using the net-margin analysis extended to test the impacts of TC as well. Here the extended net-benefit is defined as net-benefit minus TC. A culture programme in a tank was taken as a single unit and all costs, including TC borne by individual members, were subtracted from returns. Table 7 presents the outcome of the analysis.

Once the transaction costs too are taken into consideration, particularly the cost incurred for monitoring (i.e., watching the actions of poachers), community-based aquaculture loses its appeal. As Table 7 shows, only 35% of 41 tanks indicate a positive net-benefit from aquaculture once all TC are taken into account. This assumes importance when the associated institutional aspects are also taken into consideration. As indicated in Table 4, transaction costs are higher in FSC-managed tanks than in FO-managed tanks. According to Table 7, despite high relative returns in FSC-managed tanks, only 33% tanks show a positive net margin once TC is taken into account compared with 50% of FO-managed tanks. This is despite the fact that FO-managed tanks have recorded relatively low average returns. Overall, the outcome of the extended cost analyses brings up some important issues, namely, (a) the transaction cost has a substantial economic impact on a significant number of tanks; (b) the impact of the TC is particularly significant in FSC-managed tanks, which is the dominant and more productive institutional arrangement for CBA; and (c) this could create a negative impact on the adoption and sustainability of the activity in the long run.

Sensitivity Analysis without Transaction Costs

Given the fact that CBA is a risk-prone activity, a sensitivity analysis (without subtracting TC) was carried out under three scenarios, namely, (a) reduction of benefits by 5%; (b) increase of costs by 5%; and (c) *a* and *b* together. The results indicate that on average, net benefits decreased by 24%, 19%, and 43% respectively under the three scenarios. In one tank where positive net benefits were reported earlier, returns turned negative. This indicates that returns from CBA in village tanks are vulnerable to uncertainties.

Table 6: Economic performance of three institutional arrangements

Institutional Arrangement	Average Production (kg)	Average Productivity (kg/ha)	Average Value of Total Product (Rs)	Average Cost (Rs)	Average Net Margin
Farmer organization (FO)	1,816.4	132.3	50,732.8	45,841.0	4,891.8
Fisheries Sub-Committee (FSC)	2,387.8	255.0	87,733.9	44,630.3	43,103.6
Other	1,966.7	206.7	61,559.9	102,566.7	- (41,006.8)
Overall	**2,196**	**218.2**	**74,654.2**	**48,447.7**	**26,206.6**

Table 7: Results of the extended net margin analysis in tanks

Criteria	**No. Tanks with positive net margins**			
	FO managed	**FSC managed**	**Other**	**Overall**
Net benefit under pure 'production costs'	06 (60%)	16 (59%)	01 (33%)	23(58%)
'Extended' net benefit including aggregate decision making and information costs	05 (50%)	15 (55%)	01 (33%)	21(53%)
'Extended' net benefit including aggregate monitoring costs as well	05 (50%)	09 (33%)	- (0%)	14 (35%)

Despite the vulnerable situation revealed in the financial analysis CBA has usually been reported as a financially viable venture from the perspective of FOs as seed fish has been provided either free, or on subsidized basis, as a promotional encouragement from a state agency or a NGO in many tanks. Besides, organizational cash flows consider conventional costs and benefits only. On a number of occasions, revenues remitted from fish culture activities claimed a significant portion of the organizational funds of FOs, which usually have a limited portfolio of other income-generating activities. This could lead to misleading implications unless the cost of subsidized inputs and transaction costs are also taken into consideration.

Distribution of benefits from community-based aquaculture

Table 8 shows the average benefits divided (in cash and kind) among individual members and organizations under the three institutional arrangements. In a majority of tanks, a certain amount of returns were retained with organizations while the remaining benefits were distributed to individual members in the form of fish, money or both. Returns have been transferred to FOs in 28 (70%) tanks and in over 60 % of the cases this portion amounted to less than 40% of total returns. Aquaculture ventures failed completely in three tanks, which left no benefits to distribute among either individual members or organizations.

In 70% of the tanks, benefits were distributed to individuals as well. These included 7 (70%) of FO-managed tanks and 21 (75%) of FSC-managed tanks. However, in many cases, individual benefits were restricted to a portion of the unsold fish harvest and cash returns were distributed in only 19 (46%) tanks. In 16 of them, income was uniformly distributed among active members while in others benefits were distributed according to work done in a proportionate manner. In addition to benefits distributed among participants, during the event of harvesting, many non-participant community members also benefited from the harvest in terms of small quantities of fish, which could amount to a substantial portion of the harvest in aggregate.

The distribution of benefits differed widely among the three institutional arrangements. Such variations were observed in the amount of cash retained by the organizations (FO or FSC) as well as in the benefits distributed to individuals. In a few tanks, a complete portfolio of benefits (i.e., cash for FO and FSC and fish and cash for individuals) was offered to all stakeholders involved. Of the three institutional arrangements, the FSC is relatively more successful in terms of organizational benefits as well as in the magnitude of individual benefits (see Table 8). However, contribution to village food security was high in FO-managed tanks as the number of beneficiaries was higher in those tanks.

On the whole, CBA has helped village communities in two important ways. First, it has helped earn some amount of cash returns for FOs in a majority of tanks. This income, though moderate in magnitude, seems to provide relief for many FOs with poor cash flows as a means of overcoming their financial difficulties. This can be considered a benefit to the respective communities with indirect advantages to individual households too.

The second major contribution is support for village food security. Table 8 shows that an average of 6.5 kg of fish has been distributed among participant members. In margin, this can be considered a significant increment to household nutrition given the fact that average fish consumption in the area has been estimated as 25 kg per household per annum. The fish output distributed among village communities increased the supply of animal proteins to the rural poor in a significant manner.

However, despite the cash flow support for organizations and contributions to village food security, the direct benefits to individual participants seem relatively low and does not provide a strong incentive to attract participation. Given the magnitude of benefits involved, it is apparent that productivity improvements generated by CBA are not on a scale that is adequate to provide a major livelihood for all members of a given community. More equitable distribution of benefits, although contrary to the expectations of policy makers, therefore, runs the risk of further thinning out incentives for the active group. This essentially has implications for the sustainability aspect of the enterprise.

Participation in CBA and poverty

According to the household survey, incidence of poverty (i.e., percentage of households in the sample with a per capita income lower than the official poverty line) among participant and non-participant households are 26% and 20% respectively. Despite this slight gap in poverty in favour of non-participants, other income parameters do not indicate a significant difference between the two groups. The average annual household income is slightly higher in the case of participants with a higher contribution from seasonal sources (33%) compared with non-participants (26%). Variation of income is significantly high among participant households (CV = 103%) than non-participants (CV= 59%). Overall, it seems that households with variable, seasonal sources of income are more attracted towards CBA than households which depend more on regular sources of income. This is quite understandable given the fact that the opportunity cost of time is usually higher for regular income earners than those with seasonal employment.

Table 8: Distribution of benefits of community-based aquaculture among participants and organizations

Institutional arrangement	Individual benefits				Benefits retained by organizational Group					
	Fish (kg)		Money (Rs)		By FSC		By FO		By Others	
	No. Tanks	Average	No. Tanks	Average	No. Tanks	Average (Rs)	No. Tanks	Average (Rs)	No. Tanks	Average (Rs)
Farmer Organization (FO)	8	6.43	4	2236	-	-	8	27,071	-	-
Fisheries Sub-Committee (FSC)	26	6.54	15	2813	9	14,492	20	8,623	-	-
Other	1	2.0	-	-	-	-	-	-	3	23,333
Overall	**35**	**6.45**	**19**	**2691**	**9**	**14,492**	**28**	**13,893**	**3**	**23,333**

Sustainability

The data collected in the survey does not allow for an unambiguous assessment of the sustainability of CBA in terms of future continuity due to lack of long term operation of CBA tanks. Out of 41 tanks studied, only 7 tanks had continued activity for more than one cycle while one tank has entered into its fourth cycle of operation when the survey was conducted. Many tanks were in their inaugural year of operation.

The survey gathered information on the last complete production cycle, mainly for the year 2003. Many tanks had not stocked up for the ongoing 2004 cycle due to the extended drought that prevailed at the time of the survey. In tanks where the inaugural cycle of production was being undertaken, inputs had been given on a free or subsidized basis as a promotional measure. Hence, it is premature to draw any conclusions on the sustainability of the venture based on the limited information currently available.

As far as preparedness for forthcoming cycles are concerned, only in the case of 9 (33%) out of 27 tanks managed by the FSC were a part of returns (extended up to 60% of total returns) retained to finance future cycles. In these tanks, a share of returns was left aside to purchase fingerlings for the next cycle. Overall, it seems that the returns which had been set aside as institutional deposits to continue aquaculture operations in forthcoming years are quite low, which is contrary to the expectations of policy makers who advocate promoting CBA on a large scale.

A majority of constraints that were seen to affect the culture operations in tanks were institution-related (Table 9). Among them, the problem of free riders is the most prominent. This problem was reported in two-thirds of tanks in the sample. In a few tanks, it reached a crisis level where authorities had to be called in for redress. Hence, the free-rider problem has the potential to cause a significant impact on the sustainability of the system, making it difficult to rally necessary cooperation among community members. It seems that other major institutional problems, namely, conflicts in FOs and mismanagement of benefits are also more or less interlinked with the free rider problem.

In addition, the poor supply of fish seeds, natural disasters, and predators also have the potential to affect the success of the programme. However, their impact on the sustainability of the system is largely due to productivity fluctuations with indirect implications on institutional factors such as group cooperation and individual participation.

In the next section we conclude by summarizing the main findings and discuss the possible policy implications.

Table 9: Constraints for community-based aquaculture

Type of constraint	Constraint(s)	Number of tanks reported	%
Technical	Poor supply of fish seed	16	39
	Poor tank selection	2	04
	Unsuitability of cultured species	8	20
Institutional	Problem of free riders (Poaching and other problems from villagers)	27	66
	Poor participation	8	20
	Political influence	3	07
	Ambiguous legal status	3	07
	Conflicts in FO	10	24
	Mismanagement of benefits	13	32
	Problem of marketing	6	15
Other physical	Natural disasters	15	37
	Predators	14	34
	Premature harvest due to water supply uncertainty	1	02

5. Conclusions and Policy Implications

CBA in village irrigation tanks in the dry-zones of Sri Lanka is organized under three institutional arrangements. In these arrangements, either Farmer Organizations retain management responsibility within themselves or contract it out to another party. Forming a FSC, a sub-group of FO, is the dominant contractual arrangement observed in two thirds of the sample. The major advantage of this arrangement is that it limits the claims from CBA to a manageable number of beneficiaries. Further, it allows for activities to be undertaken by a limited number of active participants in an independent manner.

All three institutional arrangements involve transaction costs which vary in magnitude. There are three major types of transaction cost – information, collective decision-making, and protection of the fish harvest from poachers. While the cost for information and collective decision-making are relatively low under all three arrangements, significant differences are observed when it comes to the cost of protecting the harvest. The lowest average aggregate transaction cost is reported in FO-managed village tanks. When management is undertaken by a sub-group or a third party, there is increase in transaction cost to protect the harvest from theft or free riders.

On the whole, CBA has helped FO's to generate much needed cash returns in a majority of the tanks and moderately increased the supply of animal proteins to the rural poor. Of the three institutional arrangements discussed here, FSC is the most successful in terms of generating benefits to individual members as well as to organizations. In addition farmers who have fluctuating incomes are able to increase incomes due to CBA. Despite these achievements, however, individual benefits from CBA are low, thereby inhibiting participation in collective action. Sustainability of CBA would depend on its ability to attract and sustain the participation of farmers. Even if the programmes are found cost effective in terms of cash flow to FOs, participation is likely to be low due to inadequate incentive. Further, the transaction cost for protection from poaching is high and will influence participation of households who bear these costs. Hence, the sustainability of collective action for aquaculture would be contingent on reduction of transaction costs and enlarging the share of benefits accruing to the active participants who bear these costs.

Two issues merit special attention in terms of policy for CBA. The first is a tank's ability to achieve adequate returns for its members. According to the data, this varies substantially among tanks. Hence, selecting tanks with adequate productivity levels is important. The second is to account for transaction costs and find a mechanism for compensating individuals who bear them. Further experiments with institutional arrangements are required to understand how to reduce transaction costs and simultaneously increase the productivity of tanks as this would impact the long-term sustainability of community-based aquaculture.

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Appendix A

A brief note on community-based aquaculture

In Sri Lanka, reservoir-based freshwater fish production takes place under two major sub-systems, namely, a) inland fisheries in relatively large perennial reservoirs; and b) seasonal village tank fisheries where community-based aquaculture is practised. Even though both systems of production practically deal with the same species of freshwater fish, resource use contexts in the two systems are different from each other. Inland fisheries in large perennial reservoirs have continuous, self-recruited fish populations exploited by regular, full-time fishermen. These fisheries have been identified among the most productive artisanal inland fisheries in Asia (de Silva 1989). In contrast, less productive seasonal fisheries in village tanks cannot support a regular fishing community, under natural conditions and, therefore, annual stocking of fish fingerlings is necessary to achieve higher levels of productivity.

Typically, an aquaculture system involves a three-stage sequence, namely, a) hatchery operations; b) nursery operations; and c) grow-out operations. Seasonal tank aquaculture is basically a grow-out operation and, usually, the other two stages of operation are fulfilled outside the reservoir site. However, procurement of inputs (fingerlings) from the nursery and immediate disposal of harvested output from the tank site are also two essential steps in a seasonal tank aquaculture programme. Seasonal tank aquaculture can be described as an extensive type of aquaculture practice due to the fact that fish are stocked in relatively low densities and external inputs are scarcely used other than fish fingerlings. Once stocked, the fish are left entirely for natural feeding for their growth. Hence, the natural fertility in a tank is an important parameter that affects the final fish output. As a measure to exploit natural foods available in different niches in an optimal manner, a poly culture combination of species is usually stocked.

Given the associated conditions, aquaculture in seasonal tanks is a task left for the surrounding agrarian communities rather than fishermen as the scope for involvement of full-time regular fishing communities is quite low. Hence, in the case of the community-based aquaculture, the major rural institution involved is FOs. However, it is mainly a rural institution established for the management of minor irrigation structures for paddy-based agriculture.